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(71) Applicant: **PROFIL-Verbindungstechnik GmbH & Co. KG**
Otto-Hahn-Strasse 22-24
W-6382 Friedrichsdorf(DE)

(72) Inventor: **Müller, Rudolf R.M.**
Fasanenweg 6
W-6000 Frankfurt(DE)
Inventor: **Babej, Jiri**
Klosterweg 27
W-6302 Lich 6(DE)

(74) Representative: **Morgan, James Garnet et al**
MANITZ FINSTERWALD & ROTERMUND
Robert-Koch-Strasse 1
W-8000 München 22 (DE)

(54) Method of attaching a fastening element to a panel and combination of a panel and at least one fastening element.

(57) A method of permanently attaching a fastening element (150), such as a nut or bolt to panels (30) having a range of panel thicknesses, such as the metal panels used by the automotive and appliance industries. The fastening element (150) includes a tubular barrel portion (154) and preferably an annular bearing face (158) surrounding the barrel portion. The method includes punching a hole (42) in the panel, then plastically deforming and drawing the panel surrounding the hole into a dome or frusto-conically shaped portion (40). The panel hole is thus enlarged to receive the fastener element barrel portion (154) from adjacent the apex of the frusto-conically shaped panel portion (40) and the bearing face (158) is then driven against the panel, deforming the panel (30) to a generally planar shape. The panel surrounding the hole is thereby driven against the tubular barrel portion (154) which, in the preferred embodiment, includes radially projecting ribs (84), forming secure anti-rotation means even in very thin panels. Finally, the free end of the barrel portion is deformed radially outwardly and preferably squeezed to form a secure interlock between the fastening element and the panel.

FIG-6

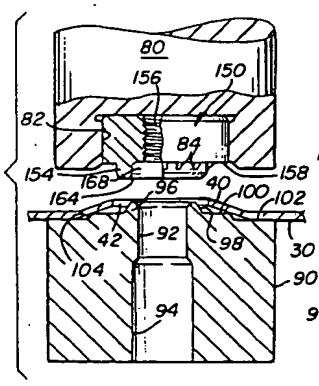
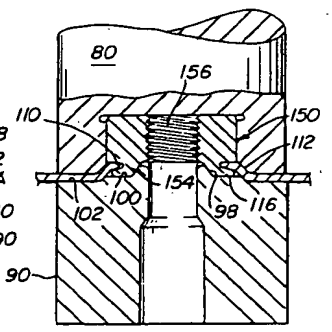


FIG-7



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BACKGROUND OF THE INVENTION

The present invention relates to methods of permanently attaching a fastening element, such as a nut or bolt, to a metal panel, and to the combination of a panel with at least one fastening element. The method of this invention is particularly useful for mass production applications, such as used by the automotive and appliance industries where a secure fastener installation is required in metal panels having a range of panel thicknesses. More specifically, the present invention relates to an improved riveting technique for flush mounting of a fastening element in panels having a range of panel thicknesses.

Pierce nuts, such as disclosed in U.S. Patent No. 2,707,322, have been widely accepted in mass production applications such as the automotive industry. More recent improvements in pierce nuts, such as shown in U.S. Patent No. 3,648,747, have resulted in improved retention of the pierce nut in the panel, although the original universal pierce nut remains a preferred installation in many applications. In both types of pierce nuts, several nuts may be installed in a metal plate or panel wherein the plate or panel may be simultaneously formed into a contoured shape, such as an automotive body panel or structural support.

More recently, fastening systems have been developed to permanently install both male and female fasteners in a panel in mass production applications, such as shown in U.S. Patent No. 4,555,838 and 4,610,072. The fastening element in such fastening systems include a tubular or annular barrel portion which is riveted to the panel during the installation. The tubular barrel portion may be utilized to pierce a slug from the panel, which may be received in the tubular barrel portion, as disclosed in U.S. Patent No. 4,55,838, or a punch may be utilized to pre-pierce the panel as disclosed, for example, in U.S. Patents 4,711,021, 4,831,698 and 4,713,872. Although such fasteners have achieved commercial success, the use of such fasteners in mass production applications has been somewhat limited by the range of panel thicknesses utilized by the automotive industry, for example, and in certain applications requiring improved torque resistance in thin panels.

The need remains for a universal fastening system utilizing conventional installation tooling which may be used for a wide-range of panel thicknesses and preferably having improved torque resistance. The improved fastener and panel assembly must also have good push out and pull through strength and be adapted for mass production applications.

SUMMARY OF THE INVENTION

The improved method of attaching a fastening element to a panel of this invention is particularly, but not exclusively adapted for permanent installation of fastening elements in plastically deformable metal panels having a range of panel thicknesses utilized in mass production applications, such as the automotive industry. The fastening element may be a female fastening element, such as a nut, or a male fastening element, such as a stud, bolt or the like. The fastening element includes a generally tubular barrel portion and preferably includes a body portion having a bearing surface surrounding the tubular barrel portion.

The method of this invention includes forming a hole through the panel which is to receive the fastening element. The method further includes drawing and plastically deforming the panel into a generally dome-shaped or frusto-conical shaped portion surrounding the hole. The inside diameter of the hole is thus large enough to loosely receive the tubular barrel portion of the fastening element. The method then includes inserting the tubular barrel portion of the fastening element through the panel hole, preferably from adjacent the apex of the frusto-conical or dome-shaped portion and the method then includes plastically deforming the panel to a generally planar shape, thereby reducing the diameter of the hole to a diameter which is less than the external diameter of the tubular barrel portion. The panel surrounding the hole is thus driven into the tubular barrel portion, increasing the torque required to rotate the fastening element in the hole. Finally, the method includes plastically deforming the free end of the barrel portion radially outwardly, forming a mechanical interlock between the panel and the fastening element.

In the most preferred method of this invention, the panel hole is formed by punching the panel with a cylindrical punch while the panel is supported on a die member. The panel is thus simultaneously drawn and deformed into the die member and punched, forming the dome or frusto-conical shaped portion of the panel surrounding the hole. Further, in the preferred method of this invention, the dome-shape portion of the panel is deformed by driving the annular bearing surface of the body portion of the fastening element against the panel surrounding the hole, deforming the panel into a generally planar shape, as described. The panel may be supported on a second die member or die button having an annular riveting surface, such that the panel is flattened and the fee end of the barrel portion is simultaneously deformed radially outwardly, forming the preferred mechanical interlock. In the most preferred method of this invention, the second die

member further deforms the radially deformed barrel portion toward the bearing surface of the body portion of the fastening element, forming a substantially flush installation of the fastening element in the panel.

The invention also comprises the combination of a panel and at least one fastener element as defined in claim 12 and more particularly also in the claims 13 to 19. Such a combination may also be found in a finished product such as a motor car or washing machine incorporating one or more panels each provided with at least one fastener.

The deformation of the material of the panel adjacent the aperture during fitting of the fastener will generally involve compressive stresses which lie above the yield stress of the panel material. Once plastic deformation of the panel material is completed in accordance with the present invention. Here will be a permanent residual compressive stress in the panel material surrounding the hole and the tubular body portion of the fastener, with this compressive stress typically and preferably lying just below the yield stress. Moreover the deformed panel portion will also exert a compressive force on the fastener element inducing a compressive stress in the latter.

These locked in compressive stresses are a good protection against fatigue cracking in use. Moreover the compressive forces tightly restrain the fastener element against rotation under applied torque during assembly with a cooperating fastener element. Once assembly is complete high axial clamping forces losses such as usually arise with nut and bolt type fastener elements secure the assembly and friction between the axially clamped surfaces resists any applied torque which may be involved in the use of the panel component.

Generally the radially deformed portion of the fastener element will lie flush with one side face of the panel so that this side face of the panel can lie flush with another panel and be pressed against it under the axial clamping load generated by a second fastener element cooperating with the first. In a relatively thinner panel the panel will generally include a residual frusto-conical portion after fitting of the fastener element to the panel. This residual frusto-conical portion ensures a high shear strength of the connection between the panel and the component mounted thereon via the fastener element. With a relatively thicker panel there is no longer a frusto-conical portion after fitting of the fastener but the residual compressive stress nevertheless ensures a good shear strength and fatigue strength of the connection.

The torque resistance of the fastening element in the panel may be further improved by providing radially projecting ribs on the barrel portion and the method of this invention is uniquely adapted to provide improved torque resistance with such ribs. As described, the internal diameter of the hole is most preferably less than the external diameter of the tubular barrel portion when the panel is relatively flat. Thus, the panel portion surrounding the hole is driven into the barrel portion as the panel is deformed from a generally dome-shape to a generally planar shape. Where the tubular barrel portion includes radially projecting ribs, the panel is driven into the ribs, as the panel is flattened, and the tubular barrel portion resiliently drives the ribs into the panel. The resultant hoop stress or radially directed strain energy results in substantially improved torque resistance, which is an important advantage of the fastening element and panel assembly of this invention. The torque resistance may also be improved by using a split tubular riveting portion, although a continuous tube is preferred.

Further, the same fastening element may be attached to metal panels having a relatively wide-range of different panel thicknesses using the same or similar installation tooling. Further, the fastening element barrel portion may be installed flush in the panel without a substantial embossure or bead. Thus, the method of installation of this invention provides the several advantages which are the objects of the invention. Other advantages and meritorious features of the method of this invention will be more fully understood from the following description of the preferred embodiments, the appended claims and the drawings, a brief description of which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side partially cross-sectioned view of an apparatus suitable for forming a hole in a panel and simultaneously forming a frusto-conical dome in the panel;

Figures 1A-1E are panels of varying thickness formed by the punching apparatus shown in Figure 1;

Figure 2 illustrates a female fastening element being received in a panel in the method of this invention;

Figure 3 illustrates the fastening element and panel of Figure 2 during the installation of the fastener in the panel;

Figure 4 illustrates the female fastening element and panel assembly attached as shown in Figures 2 and 3;

Figure 5 is a side partially cross-sectioned view of a female fastening element and panel assembly similar to Figure 4, except with a thicker panel;

Figures 6 and 7 illustrate the installation of a further embodiment of a female fastening ele-

ment being installed in a relatively thin panel using one embodiment of an installation apparatus;

Figures 8 and 9 illustrate the installation of one embodiment of a male fastening element in a panel using an installation apparatus similar to the installation apparatus shown in Figures 6 and 7;

Figure 10 is an end view of the embodiment of the female fastening element shown in Figures 6 and 7;

Figures 11 and 13 are partially cross-sectioned views of a female fastening element, panel and installation apparatus illustrating the installation of the female fastening element shown in Figure 10;

Figure 12 is an enlarged partial cross-sectioned view of an intermediate step in the installation of the female element as shown in Figures 11 and 13; and

Figure 14 is a partial cross-sectioned view, similar to Figures 6 and 7, illustrating the deformation of the panel during the installation of a fastening element.

DESCRIPTION OF THE PREFERRED METHODS OF INSTALLATION OF THIS INVENTION

Figure 1 illustrates one embodiment of a punch apparatus suitable for punching and forming a panel in accordance with the method of this invention. The punch apparatus includes a punch 20 having a body portion 22 and a punch portion 24. In the disclosed embodiment, the punch portion 24 is cylindrical and has a diameter smaller than the diameter of the body portion 22 to receive a plastic spring member 26. The spring member 26 includes a cylindrical bore 28 which closely receives the cylindrical punch portion 24 of the punch. Plastic springs of the type shown in Figure 1 are commercially used for stripping the panel 30 from the punch and are sometimes referred to as a stripper. In the disclosed embodiment, however, the plastic spring functions not only as a stripper, but also deforms the metal panel in the die member 32, as described below. Such plastic springs are generally formed from a high density polyurethane.

The die member 32 includes an annular die cavity 34 and a cylindrical bore 36 which receives the panel slug 38. The method steps performed by the apparatus shown in Figure 1 thus includes two steps. The cylindrical punch portion 24 punches a circular slug 38 from the panel 30, forming a circular opening or hole 42 in the panel. The panel is substantially simultaneously drawn and deformed into the annular die cavity 34 by the punch portion 24 and the plastic spring 26, forming a frustoconical panel portion 40 adjacent the hole 42, as best shown in Figures 1A-1E discussed below. Depending upon the panel hardness and thickness, the panel may be drawn into the die cavity 34 and then punched or the steps may be separately performed. The panel slug 38 is removed through the cylindrical bore 36 of the die member.

Figures 1A-1E illustrate cross-sections of panels of varying thickness punched and formed with the apparatus illustrated in Figure 1. As described above, the method of attaching a fastening element to a panel of this invention is suitable for attaching a fastening element to panels of different or varying thickness, such as utilized by the automotive industry. The panel shown in Figure 1A, for example, has a thickness of 0.75-0.80 millimetres (mm). The panel illustrated in Figure 1E has a thickness of about 4 mm, which illustrates the range of panel thicknesses typically utilized by the automotive industry. Such panels are generally formed of steel, such as AISI 1008 or 1010 steel, which may be hot or cold rolled and are generally of commercial draw quality. Similar panels are used by many other industries. The appliance industry uses corrosion resistant and antimagnetic steels which are particularly suitable for the method of this invention because of their relatively poor weldability. Panels are used by the automotive industry for body panels, brackets and structural supports. The method of this invention may also be used to permanently install fastening elements in aluminium, copper and brass panels and other panels which require and installation of the type described herein. It is important to note, however, that the punch and forming apparatus shown in Figure 1 may be utilized to punch and form panels having a wide-range of panel thicknesses, such as illustrated in Figures 1A-1E.

As illustrated in Figures 1A and 1B, the thinner panels are punched and formed without extruding panel metal. In the thicker panels having a thickness greater than about 2.5 mm, a lip 44 is extruded axially by the punch portion 24, see 44C in Figure 1C, 44D in Figure 1D and 44E in Figure 1E. This extruded lip aids in the retention of the fastening element on the panel, as described below. As will be understood by those skilled in the art, the panel may also be punched and formed in separate operations on the frustoconical portion 40 may be formed in a configured die. A configured die would, however, require a separate die for a much smaller range of panel thicknesses, which would be a disadvantage in mass production applications where panels of different thickness are routinely used. The panel portion 40 may be characterized as frusto-conical shape or dome shape, wherein such terms are meant to include arcuate forms.

Figures 2 – 5 illustrate a female fastening element which may be installed in a panel 30 by the method of this invention. As used herein, the term fastening element refers to a male or female fastening element preferably including a fastening portion, such as a threaded portion, which may be utilized to attach the panel to a second structural element, such as a panel, bracket or the like. Such fastening elements would therefore include a nut or bolt, as illustrated, and other fastening elements, including the male or female components of a ball joint and the like.

The female fastening element or nut 50 illustrated in Figure 2 includes a body portion 52 and an annular or tubular barrel portion 54, preferably integral with the body portion and coaxially aligned with the threaded bore 56. The body portion 52 preferably includes an annular bearing face or surface 58, which preferably surrounds the tubular barrel portion 54, and a driven face 60. The free end 62 of the barrel portion 54 in the disclosed embodiment includes an annular internal chamber 64 and an arcuate outer surface 66. The internal surface 68 of the barrel portion is preferably smooth and the external surface 70 in the disclosed embodiment is cylindrical. As described below, however, the external surface 70 may be polygonal to provide improved torque resistance, including octagonal or hexagonal.

In the method of this invention, the barrel portion 54 is preferably received through the panel hole 42 from adjacent the apex of the frusto – conical portion 40. That is, the fastening element is preferably received from the side of the panel opposite the side through which the punch 24 is received, as shown in Figure 1. Further, the diameter of the exterior surface 70 of the pilot portion is less than the internal diameter 42 of the domed panel. In the most preferred method, the barrel portion 54 is loosely received in the domed panel hole 42, reducing alignment problems. Figures 3 – 5 illustrate fastening element and panel assemblies which may be formed by the method of this invention.

Figures 6 and 7 illustrate an embodiment of an installation apparatus suitable for installing fastening elements of the type described. The installation apparatus includes a plunger 80 having a configured cavity 82, which receives and supports the nut 150, and a die member 90 which supports the panel 30 during installation of the fastening element and which deforms the pilot portion 154 radially outwardly to form a mechanical interlock with the panel 30, as now described. Reference may also be made to U.S. Patents 4,543,701, 4,555,838 and 4,610,072 which disclose self – piercing and riveting fastening elements having a tubular barrel portion. The fastening element 150 illustrated in Figures 6, 7 and 10 – 14 may be identical to the fastener 50 illustrated in Figures 2 – 5, except that the female fastening element 150 includes radially projecting anti – rotation ribs 84 as best illustrated in Figures 6, 10 and 11. The anti – rotation ribs 84 are generally triangular and integrally joined to the bearing surface 158 of the body portion 152 and the external surface 170 of the barrel portion 154. The numbering of the elements of the female fastening element 150 is therefore the same sequence as the fastening element 50.

The die member 90 is generally referred to as a die button. In a disclosed embodiment, the die button 90 includes axial bores 92 and 94 which relieve pressure during the installation of the fastening element 150. The die face includes a central projecting die post 96 having a frusto – conical side face 98, a first flat annular surface 100 and a second flat annular surface 102, joined to the first annular surface 100 by a second conical surface 104. As described above, the pilot portion 154 is loosely received in the hole 42 through the panel and the annular bearing face 158 is then driven against the panel adjacent the hole 42, deforming the frusto – conical panel portion 40 to a generally planar configuration as shown in Figure 7. The panel is deformed into a radially projecting portion 110 and a conical portion 112.

In the apparatus illustrated in Figures 6 and 7, the tubular barrel portion 154 is simultaneously deformed radially outwardly, as now described. The inside chamber 164 at the free end of the barrel portion is first received against the conical surface 98 of the die button post followed by the inside surface 168 of the barrel portion. These surfaces are then received against the annular flat surface 100, forming a radially outwardly projecting lip 116, as shown in Figure 7. The annular surface 100 simultaneously deforms the radially projecting barrel portion 116 toward the bearing surface 158 of the body portion, squeezing the assembly and forming an intimate laminate comprising the radially projecting barrel portion 116, the radially projecting panel portion 110 and the bearing surface 158. A secure mechanical interlock is thus formed between the fastening element 150 and the panel 30.

Further, as described above, the internal diameter of the hole 42 in the panel 30 in the flattened condition shown in Figure 7 is less than the external diameter of the barrel portion 154. The radially projecting panel portion 110 is thus driven radially inwardly against the external surface of the barrel portion into the radially projecting ribs 84, driving the ribs into the panel. Further, the tubular barrel portion resiliently resists radial deformation, driving the ribs into the radially projecting panel portion 110. The stress thus created is commonly

referred to as hoop stress after the stress created by a barrel hoop or stay. That is, strain energy is directed radially inwardly against the barrel, which is resisted by the resilient tubular barrel portion. It will be understood, however, that all applications do not require anti-rotation ribs and even a smooth barrel will provide some resistance to rotation because of the method of this invention. Further, the barrel portion 154 may be polygonal and inserted into a circular hole. A circular hole is, however, preferred to avoid stress risers.

Figures 8 and 9 illustrate a method of installing a male fastening element 250. As shown, the male fastening element is installed in a relatively thin panel of approximately the same thickness as the panel 30 shown in Figures 6 and 7. The male fastening element 250 includes a tubular or annular barrel portion 254 having a free end 262 configured as described above in regard to the fastening element 50 in Figure 2. The body portion 252 of the male fastening element has been modified somewhat to provide an enlarged bearing surface 258 which will provide direct clamp loading of the fastener assembly, as will be understood by those skilled in the art. Of course, the male fastening element also includes a threaded shank or bolt portion 320 which is formed integrally with the fastener and coaxially aligned with the barrel portion 254. The plunger cavity 282 has been modified to conform to and receive the body portion 252 of the male fastening element; however, the installation of the male fastener element is substantially identical to the method described above in regard to Figures 6 and 7 and the die button 90 may be identical to the die button shown in Figures 6 and 7. As shown in Figure 8, the barrel portion 254 is first received through the hole 42 in the panel 30 and the bearing surface 258 is driven against the panel, deforming the panel into the generally planar configuration shown in Figure 9, including a radially projecting portion 210 and a generally conical portion 212. The barrel portion 254 is deformed radially outwardly by the conical face 98 and the flat 100, forming a radially projecting portion 216, as shown in Figure 9. The radially projecting panel portion 210 is driven into the radially projecting ribs 284, forming secure anti-rotation means. Thus, the method of installing the male fastener 250 is substantially identical to the method of installing the female fastener 150 as described above in regard to Figures 6 and 7.

Figures 6 - 9 illustrate a fastening element installed "downwardly", wherein the fastening element 150 or 250 is received and retained in a plunger 80 or 280 and the plunger is driven downwardly to engage the fastening element with a die button 90. In mass production applications, where the fastening element may be installed in a progressive die, the fastening element may be installed upwardly as would be illustrated by turning Figures 6 - 9 upside down. Alternatively, the panel can be turned over after the panel is punched and formed as shown in Figure 1. In the preferred method of this invention, the panel should be softer than the nut. Most preferably, the hardness of the panel should be less than about 60 % of the hardness of the nut. The fastening element should have hardness and strength characteristics typical of those fasteners which meet the requirements of ISO Classes 8 through 12. The fastener may be formed from AISI 1035 steel and heat treated to the appropriate hardness. Thus, the method of this invention may be utilized to install fastening elements in most panels used in mass production applications. Further, it is important to note that the same fastener may be installed in panels having a wide range of thicknesses using the same or very similar installation tooling.

Figures 10 - 14 illustrate important details of the method of attaching fastening elements to a panel, particularly a thickener panel, as shown in Figure 1E, above. The fastening element 150 has been described above in regard to Figure 6. The fastening element includes a tubular barrel portion 154 and a plurality of radially projecting ribs 84. As shown in Figure 11, the fastening element 150 is installed in a relatively thick panel 30E using the same tooling as used in the thin panel shown in Figure 6. That is, the fastening element is received and supported within a cavity 82 in a plunger or punch 80 and driven through the panel opening 42E against the conical side surface 98 of the die post. The bearing surface 158 of the body portion 152 first engages the extruded portion 44E and the ribs 84 begin to bite into the panel as shown in Figure 12. Finally, the annular die surface 100 is driven into the now radially projecting panel portion 110 and the free end 116 of the barrel portion is deformed radially outwardly as shown in Figure 13, forming a secure installation. The extruded metal 44E helps to fill the C-shaped radially outwardly opening annular cavity formed by the barrel portion 154 and bearing surface 158 as shown in Figure 13.

Figure 14 illustrates the deformation of the panel 30 during the installation of the fastener 150. As shown in Figure 14, the hole 42 through the frusto-conical portion 40 has an inside diameter greater than the external diameter of the barrel portion 154, such that the barrel portion 154 is loosely received in the panel hole 42 during the installation of the fastening element. The panel is then deformed to a generally planar configuration, as shown, wherein the hole 42 has a diameter which is slightly less than the external diameter of the barrel portion 154. As described above, the

panel is thus driven radially inwardly against the barrel portion during the final installation of the fastening element, improving the resistance to rotation of the fastening element in the panel.

It should now be evident to a person skilled in the art, comparing the fastening element and panel installation shown in Figures 4, 5, 7 and 9, that the method of attaching a fastening element of this invention may be utilized to install fastening elements to panels having a wide range of panel thicknesses using the same fastening element and tooling. As shown in Figures 3 and 4, the fastening element 50 is installed in a panel having an intermediate thickness such as shown, for example, in Figure 1B. The radially deformed barrel portion 54 is flush with the panel 30. The panel does include a slight emboss 31, but the emboss is substantially less than the emboss formed in most applications. Figure 5 illustrates an installation of the female fastener 50 in a relatively thick panel, such as a panel having a thickness of 4 mm. The panel 30E has no emboss and the barrel portion 54 is flush with the panel. Finally, Figures 7 and 9 illustrate the installation of both male and female fastening elements in a relatively thin panel, such as the panel shown in Figure 1B. The panel 30 does include a more substantial emboss, but the emboss is less than that formed by other methods and the radially deformed barrel portion 216 is flush or actually recessed in the panel 30.

Thus, the method of installing a fastening element of this invention may be utilized to install both male and female fastening elements in panels having a relatively wide range of panel thicknesses. In the illustrated embodiments, the fastening elements are installed in panels ranging in thickness from 0,75 mm to 4 mm. In testing of the fastening element and panel assembly, the push out strength was found to be more consistent with a wider range of panel thicknesses than prior methods discussed above. More importantly, the fastening element and panel assembly shows improved torque resistance with thinner panels. For example, a 25 % increase in torque resistance was found in a 0.8 mm panel compared to the fastener and panel assembly shown in U.S. Patent 4,831,698. Thus, the method of permanently attaching a fastening element to a plastically deformable panel of this invention achieves the goals of the invention discussed above.

As will be understood, various modifications may be made to the disclosed male and female fastening elements, installation tooling and method disclosed and described in regard to Figures 1 - 14, without departing from the purview of the invention. For example, the fastening element may have a polygonal barrel portion to further improve the torque resistance of the fastening element in the panel. The frusto-conical or dome-shaped portion 40 may be modified by using a configured die. However, in the preferred method of this invention, the panel hole is enlarged during the doming step, such that the barrel portion is loosely received in the panel hole during the final installation step. Thus, the method of this invention will be particularly useful for such applications as safety bolt anchors for automotive seat belt installations, particularly, in thinner panel metals. Further, the fastening element may be installed in very thin panel metals now being used by both the automotive and appliance industries. Thus, it is anticipated that the method of this invention will find a broad range of applications.

To summarise, the invention comprises a method of attaching a fastening element to a plastically deformable panel, said fastening element including a generally tubular barrel portion, said method comprising the steps of:

(a) forming a hole through said panel;

(b) drawing and plastically deforming said panel into a generally dome-shaped portion surrounding said hole with said hole at a smaller diameter of said dome-shaped portion and said dome-shaped portion having side walls sloping towards the center of said hole;

(c) inserting said generally tubular barrel portion of said fastening element through said panel hole;

(d) plastically deforming said panel dome-shaped portion into a generally planar shape, thereby reducing the diameter of said hole and forcing the surrounding panel into engagement with said tubular barrel portion; and

(e) plastically deforming an end of said generally tubular barrel portion radially outwardly forming a mechanical interlock between said panel and said fastening element.

A particularly important aspect of the method of attaching a fastening element to a plastically deformable metal panel, said fastening element including a body portion and a tubular barrel portion extending from said body portion and said body portion having an annular bearing surface surrounding said tubular barrel portion, comprises the steps of:

(a) forming a hole through said panel;

(b) forcing a plastic member against said panel adjacent said hole thereby drawing and plastically deforming said panel into a generally frusto-conical portion surrounding said hole with said hole at a smaller diameter of said frusto-conical portion;

(c) inserting said tubular barrel portion through said hole from adjacent the apex of said generally frusto-conical portion and said bearing surface of said body portion engaging a panel

portion surrounding said panel hole; and

(d) driving said body portion annular bearing surface of said fastening element against said panel portion surrounding said hole plastically deforming said panel frusto-conical portion to a generally planar shape, thereby reducing the internal diameter of said hole into engagement with said tubular barrel portion and substantially simultaneously plastically deforming a projecting free end of said tubular barrel portion radially outwardly entrapping said panel portion between said annular bearing surface and said radially deformed free barrel portion end.

Alternatively this method aspect can be described as a method of attaching a fastening element to plastically deformable metal panels having a range of panel thicknesses, said fastening element having a body portion and a tubular barrel portion extending from said body portion and said body portion having a bearing face on at least opposed sides of said barrel portion, said method comprising the steps of:

(a) forcing a plastic member against said panel adjacent said hole thereby drawing and deforming said panel into a generally conical shape and substantially simultaneously punching a hole in said panel adjacent an apex of said conical portion, said hole having an inside diameter greater than an outside diameter of said barrel portion to loosely receive said barrel portion;

(b) inserting a free end of said barrel portion through said panel hole and driving said fastening element body portion bearing face against a panel portion adjacent said hole, deforming said conical panel portion to a substantially planar shape, said hole reducing in size as said panel is deformed and driving said panel portion against said tubular barrel portion; and

(c) plastically deforming said barrel portion free end radially outwardly forming a mechanical interlock between said panel (30) and said fastening element.

The method of the invention for attaching a fastening element to a plastically deformable panel, said fastening element including a generally tubular barrel portion surrounded by a radial flange, can also be regarded as comprising the steps of:

(a) forming a hole through said panel;

(b) plastically deforming said panel into a generally frusto-conical portion surrounding said hole;

(c) inserting said generally tubular barrel portion of said fastening element through said panel hole,

(d) constricting an edge portion of said hole thereby reducing the diameter of said hole and forcing said panel into engagement with said tubular portion,

(e) plastically deforming an end of said tubular barrel portion radially outwardly thereby pinching said panel between said deformed end of said tubular barrel portion and said radial flange.

The invention also relates to a riveting fastener and panel assembly, comprising: a panel, a riveting fastener including a tubular riveting barrel portion having a free end and a body portion having a diameter greater than said barrel portion, said body portion having a side wall and a radial bearing surface extending between said barrel portion and said body side wall, said panel having an opening therein, said tubular barrel portion received through said panel opening and said barrel portion free end radially deformed to engage said panel and to pinch said panel between said radially deformed barrel portion and said bearing surface, said portion of said panel pinched between said deformed barrel portion and said bearing surface being generally parallel to said radial bearing surface of said fastener.

Here the riveting fastener and panel assembly preferably has a fastener body which includes a threaded bore defining first and second openings.

The riveting fastener and panel assembly may be such that said threads begin at said first opening and travel into said bore toward said second opening stopping short of said second opening.

Furthermore, said second opening may include an arcuate, chamfered portion for receiving and guiding a threaded male fastener into said bore. A surface of said fastener is generally flush with a surface of said panel.

Furthermore, said portion of said panel pinched between said deformed barrel portion and said bearing surface may be displaced from a plane of said panel. Said bearing surface of said fastener is preferably embedded into said panel.

Moreover, said pinched panel portion preferably substantially fills the space between said fastener deformed barrel portion and said fastener bearing surface. Said fastener body can further include a stud portion encircled by said tubular riveting barrel portion.

Moreover, said stud portion can be threaded and said body portion of said fastener may usefully include an arcuate trough surrounding said stud portion. The riveting fastener and panel assembly can also be regarded as comprising: a panel member having a first and second generally parallel planar portions, said first and second planar portions joined by frusto-conical side walls extending between said first and second planar portions, said second planar portion including an opening therethrough, a riveting fastener including a tubular riveting panel portion having a free end

and a body portion having a diameter greater than said barrel portion, said body portion having a side wall and a radial bearing surface extending between said barrel portion and said body side wall, said tubular barrel portion disposed within said panel opening and barrel portion free end radially deformed to engage said panel and to secure said panel between said radially deformed barrel portion and said radial bearing surface.

Alternatively the riveting fastener and panel assembly can be regarded as comprising: a panel, a stud, riveting fastener including a tubular riveting barrel portion, a stud portion, and a body portion, said tubular riveting portion extending from said body portion and encircling said stud portion, said tubular riveting portion having a free end and said body portion having a diameter greater than said barrel portion, said body portion having a side wall and a radial bearing surface extending between said barrel portion and said body side wall, said panel having an opening therein, said tubular barrel portion received through said panel opening and said barrel portion free and deformed radially to engage said panel and to pinch said panel between said radially deformed barrel portion and said bearing surface. Said stud portion is typically threaded.

Moreover, said body portion of said fastener expediently includes an arcuate trough surrounding said stud portion. The riveting stud fastener itself usefully comprises: an elongated body member and a head portion, said elongated body integrally joined, and extending from said head portion, said head portion including a tubular barrel portion encircling said elongated member, said head portion further including an annular trough encircling said tubular barrel portion, wherein a portion of said trough surface defines a radial bearing surface, and wherein said head portion includes projections extending from said radial bearing surface.

Claims

1. A method of attaching a fastening element (50, 150, 250) to a plastically deformable panel (30), said fastening element including a generally tubular barrel portion (54, 154, 254), said method comprising:
   (a) forming a hole (42) through said panel;
   (b) drawing and plastically deforming said panel (30) into a generally dome-shaped portion (40) surrounding said hole (42) with said hole at a smaller diameter of said dome-shaped portion;
   (c) inserting said generally tubular barrel portion (54, 154, 254) of said fastening element (50, 150, 250) through said panel hole (42);
   (d) plastically deforming said panel dome-shaped portion into a generally planar shape, thereby reducing the diameter of said hole (42) and the surrounding panel into engagement with said tubular barrel portion (54, 154, 254); and
   (e) plastically deforming an end of said generally tubular barrel portion radially outwardly forming a mechanical interlock between said panel (30) and said fastening element (50, 150, 250).

2. The method of attaching a fastening element (50, 150, 250) to a panel as defined in claim 1, wherein said hole (42) is formed by punching said panel (30) with a generally cylindrical punch (24), said panel (30) being supported on a die element (32), said panel (30) thus being simultaneously drawn and deformed into said dome-shaped portion (40) in said die element (32) and punched to form said hole.

3. The method of attaching a fastening element to a panel as defined in claim 1 or claim 2, wherein said fastening element includes a body portion (52, 152, 252) and said barrel portion (54, 154, 254) extending from said body portion, said body portion including an annular bearing surface (58, 158, 258) surrounding said barrel portion having a diameter greater than said panel hole (42), said method including inserting said barrel portion (54, 154, 254) into said panel hole (42) from adjacent said smaller diameter of said dome-shaped panel portion and driving said annular driving surface (58, 158, 258) against said panel adjacent said hole, thereby deforming said dome-shaped panel portion (40) to said generally planar shape,
   wherein said barrel portion (54, 154, 254) is preferably received through said panel hole (40) into a die member (90), said method preferably including driving said fastening element bearing surface against said panel to deform said panel (30) and substantially simultaneously deforming said barrel portion (54, 154, 254) radially outwardly in said die member (90),
   said die member (90) preferably including a central post (96) having a projecting end portion and a generally conical side surface (98) receiving an inside surface of said tubular barrel portion, said conical surface, deforming said free end of said barrel portion radially outwardly (116, 216) and entrapping a radially projecting portion (110, 210) of said panel (30) adjacent said hole between said radially deformed free end (116, 216) of said barrel

portion and said bearing surface of said body portion; and
wherein said method optionally further includes pressing said barrel portion free end (116, 216) toward said bearing surface (58, 158, 258) thereby squeezing said radially projecting panel portion (110, 210), forming an intimate laminate and a substantially flush installation of said fastening element (50, 150, 250) in said panel (30).

4. A method of attaching a fastening element to a plastically deformable metal panel, said fastening element including a body portion (52, 152, 252) and a tubular barrel portion (54, 154, 254) extending from said body portion and said body portion having an annular bearing surface (58, 158, 258) surrounding said tubular barrel portion, said method comprising the following steps:
(a) forming a hole (42) through said panel (30);
(b) drawing and plastically deforming said panel (30) into a generally frusto-conical portion (40) surrounding said hole (42) with said hole at a smaller diameter of said frusto-conical portion;
(c) inserting said tubular barrel portion (54, 154, 254) through said hole from adjacent the apex of said generally frusto-conical portion (40) and said bearing surface (58, 158, 258) of said body portion (54, 154, 254) engaging a panel portion surrounding said panel hole; and
(d) driving said body portion annular bearing surface (58, 158, 258) of said fastening element against said panel portion surrounding said hole plastically deforming said panel frusto-conical portion (40) to a generally planar shape, thereby reducing the internal diameter of said hole (42) into engagement with said tubular barrel portion (54, 154, 254) and substantially simultaneously plastically deforming a projecting free end (116, 216) of said tubular barrel portion radially outwardly entrapping said panel portion (40) between said annular bearing surface (58, 158, 258) and said radially deformed free barrel portion end (116, 216).

5. The method of attaching a fastening element to a panel as defined in claim 4, wherein said panel is supported on a die element (32) having an annular die cavity (34), said method including driving a punch (20) against said panel (30), deforming and drawing said panel (30) into said die member cavity (34) into said frusto-conical panel portion and punching a hole (42) in said panel (30).

6. The method of attaching a fastening element to a panel as defined in claim 5, wherein said punch (20) forms an axially projecting lip (44C, 44D, 44E) surrounding said hole (42), said method including driving said bearing surface (58, 158, 258) against said lip and deforming said lip (44C, 44D, 44E) between said bearing surface (58, 158, 258) and said radially deformed barrel portion (54, 154, 254).

7. The method of attaching a fastening element to a panel as defined in any one of claims 4 to 6, wherein said frusto-conical panel portion (40) is received and supported on a die member (90), said die member (90) including a central die post (96) having a projecting end portion coaxially aligned with said fastening element tubular barrel portion and a conical side surface (98) receiving an inside surface (68, 168) of said tubular barrel portion (54, 154, 254), said conical die surface deforming a free end (116, 216) of said barrel portion radially outwardly, entrapping a radially extending portion (110, 210) of said panel adjacent said panel hole between said radially deformed barrel portion free end (116, 216) and said body portion annular bearing surface (58, 158, 258), said method preferably comprising the further step of pressing said barrel portion free end (116, 216) toward said bearing surface (58, 158, 258), thereby squeezing said panel (30) and forming an intimate laminate comprising said barrel portion free end (116, 216), said panel (30) and said bearing surface (58, 158, 258).

8. The method of attaching a fastening element to a panel as defined in any one of the preceding claims 4 to 7, wherein an outside diameter of said tubular barrel portion (54, 154, 254) is smaller than an internal diameter of said panel hole (42), said tubular barrel portion thus being freely received in said panel hole of said frusto-conical panel portion (40) and said method including driving said panel (30) into said barrel portion (54, 154, 254) as said frusto-conical panel portion (40) is deformed to a generally planar shape, reducing the diameter of said hole (42) to a diameter less than said outside diameter of said tubular barrel portion (54, 154, 254), and wherein said barrel portion optionally includes a plurality of spaced radially projecting ribs (84, 284) adjacent said body portion bearing surface and said method including driving said panel radi-

ally into said ribs as frusto-conical panel portion (40) is deformed to a generally planar shape, said tubular barrel portion (54, 154, 254) elastically driving said ribs into said panel, forming a secure anti-rotation means between said fastening element (50, 150, 250) and said panel (30).

9. A method of attaching a fastening element to plastically deformable metal panels having a range of panel thicknesses, said fastening element (50, 150, 250) having a body portion (52, 152, 252) and a tubular barrel portion (54, 154, 254) extending from said body portion and said body portion having a bearing face (58, 158, 258) on at least opposed sides of said barrel portion, said method comprising:

(a) drawing and deforming said panel (30) into a generally conical shape (40) and substantially simultaneously punching a hole (42) in said panel adjacent an apex of said conical portion, said hole (42) having an inside diameter greater than an outside diameter of said barrel portion (54, 154, 254) to loosely receive said barrel portion;

(b) inserting a free end (116, 216) of said barrel portion through said panel hole and driving said fastening element body portion bearing face (58, 158, 258) against a panel portion (40) adjacent said hole, deforming said conical panel portion (40) to a substantially planar shape, said hole (42) reducing in size as said panel is deformed and driving said panel portion (110, 210) against said tubular barrel portion; and

(c) plastically deforming said barrel portion free end (116, 216) radially outwardly forming a mechanical interlock between said panel (30) and said fastening element (50, 150, 250);

wherein said fastening element barrel portion optionally includes a plurality of spaced radially projecting ribs (84, 284) adjacent said bearing face, said method then including driving said panel portion (40) radially into said ribs as said conical panel portion (40) is deformed to a generally planar shape and said tubular barrel portion (54, 154, 254) elastically driving said ribs into said panel portion, forming secure anti-rotation means between said fastening element and said panel; and wherein said method preferably further includes pressing said barrel portion free end (116, 216) toward said bearing surface (58, 158, 258) of said body portion, thereby squeezing said panel portion (40) and forming an intimate laminate of said radially deformed barrel portion free end (116, 216), a radially projecting panel portion (110, 210) and said bearing surface (58, 158, 258) of said body portion.

10. The method of attaching a fastening element to a panel is defined in claim 9, wherein said hole (42) is formed by a punch (20) while said panel is supported on a die member (32) having an annular die cavity (34), said punch punching a hole (42) in said panel and simultaneously plastically deforming and drawing said panel (30) surrounding said hole in said die member die cavity into said generally conical shaped portion (40).

11. The method of attaching a fastening element to a panel as defined in claim 9 or claim 10, wherein said method includes driving said fastening element body portion bearing surface 58, 158, 258) against said panel portion adjacent said hole, deforming said conical panel portion (40) to a generally planar shape and substantially simultaneously deforming said free end (116, 216) of said tubular barrel portion radially outwardly to form said mechanical interlock.

12. The combination of a plastically deformable panel (30) and at least one fastening element (50, 150, 250) passing through an aperture (92) in said panel (30) and having a radially deformed portion (116, 216) at the opposite side of said panel thus forming a mechanical interlock between said panel and said fastener characterized in that the material of said panel adjacent said aperture has a permanent compressive stress less than but preferably substantially equal to at least 50 % more particularly at least 80 % and especially almost 100 % of the yield stress of said plastically deformable material.

13. The combination in accordance with claim 19, characterized in that said permanent compressive stress is a hoop stress.

14. The combination in accordance with claim 12 or claim 13, characterized in that said panel exerts a permanent compressive force on at least a major portion of the surface (70 and/or 116, 216; 58, 158, 258) of said fastener in mechanical interlocking engagement with said panel.

15. The combination in accordance with any one of claims 12 to 14, characterized in that said one side of said panel is coplanar with an outer

surface of said radially deformed portion (116, 216) so that said radially deformed portion does not project beyond said one side in the direction away from said opposite side.

16. The combination in accordance with claim 15, wherein said one side of said panel (30) is placed in use adjacent a side of a further panel lying parallel to it and is preferably secured thereto, at least in part, by a fastening element cooperating with said at least one fastener (50, 150, 250).

17. The combination in accordance with any one of claims 12 to 16, characterized in that said aperture (42) in said panel (30) is formed in a portion of said panel which merges via a substantially frusto-conical portion (31, 112, 212) of said panel into the remainder of said panel (30), with said radially deformed portion (116, 216) of said fastener lying generally within said frusto-conical portion.

18. The combination in accordance with any one of claims 12 to 17, characterized in that said fastener has a barrel portion (54, 154, 254) removed said aperture and is provided with formations such as radially projecting rounded ribs (84, 284) or corners, e.g. corners of a generally polygonally shaped barrel portion.

19. The combination in accordance with any one of the preceding claims 12 to 18, characterized in that the hardness of said panel (30) is less than about 60 % of the hardness of the fastener (50, 150, 250).

20. A riveting fastener and panel assembly, comprising:
a panel,
a riveting fastener including a tubular riveting barrel portion having a free end and a body portion having a diameter greater than said barrel portion, said body portion having a side wall and a radial bearing surface extending between said barrel portion and said body side wall, said panel having an opening therein, said tubular barrel portion received through said panel opening and said barrel portion free end radially deformed to engage said panel and to pinch said panel between said radially deformed barrel portion and said bearing surface, said portion of said panel pinched between said deformed barrel portion and said bearing surface being generally parallel to said radial bearing surface of said fastener.

21. A riveting fastener and panel assembly, comprising:
a panel,
a stud, riveting fastener including a tubular riveting barrel portion, a stud portion, and a body portion, said tubular riveting portion extending from said body portion and encircling said stud portion, said tubular riveting portion having a free end and said body portion having a diameter greater than said barrel portion, said body portion having a side wall and a radial bearing surface extending between said barrel portion and said body side wall, said panel having an opening therein, said tubular barrel portion received through said panel opening and said barrel portion free and deformed radially to engage said panel and to pinch said panel between said radially deformed barrel portion and said bearing surface.

22. A riveting stud fastener, comprising:
an elongated body member and a head portion, said elongated body integrally joined, and extending from said head portion, said head portion including a tubular barrel portion encircling said elongated member,
said head portion further including an annular trough encircling said tubular barrel portion, wherein a portion of said trough surface defines a radial bearing surface, and wherein said head portion includes projections extending from said radial bearing surface.

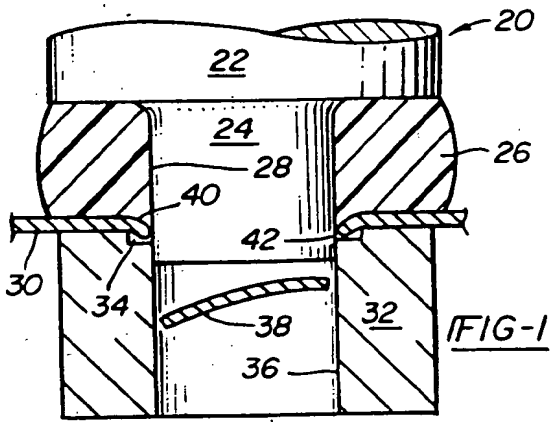


FIG-1

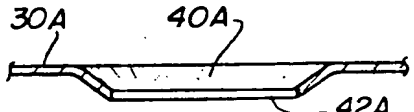


FIG-1A

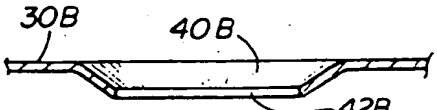


FIG-1B

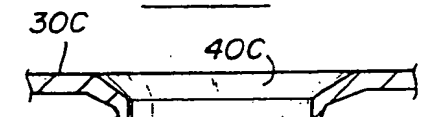


FIG-1C

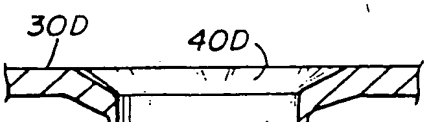


FIG-1D

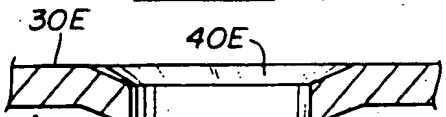


FIG-1E

FIG-2

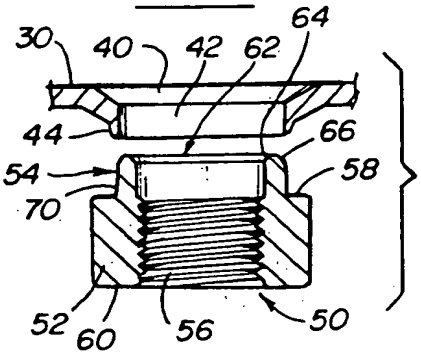


FIG-3

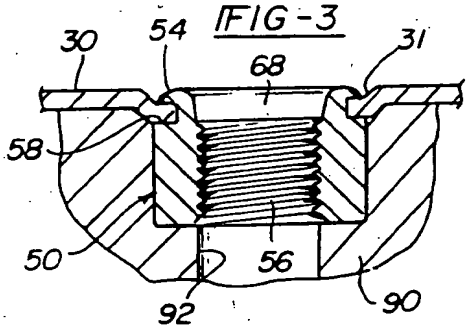
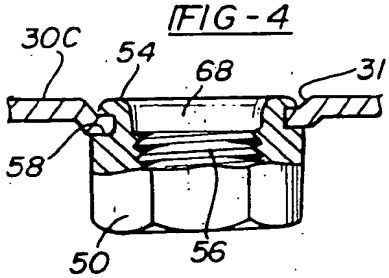


FIG-4



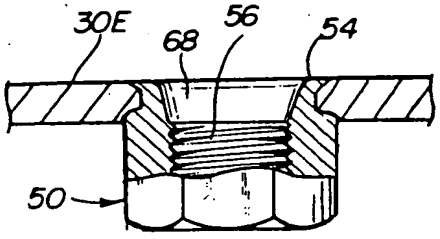


FIG-5

FIG-6

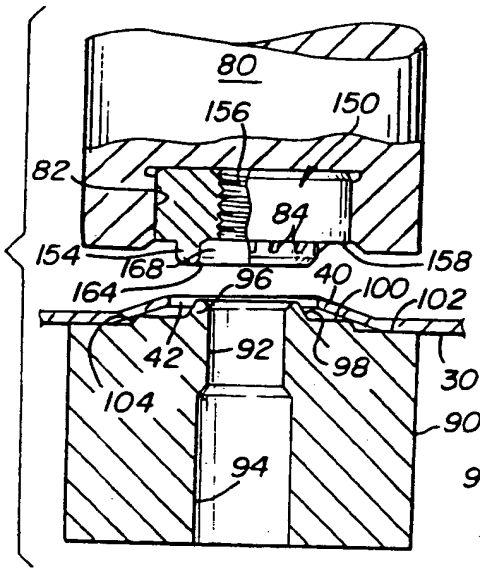


FIG-7

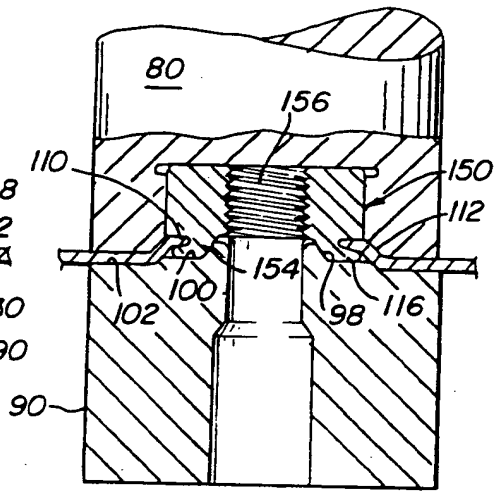


FIG-8

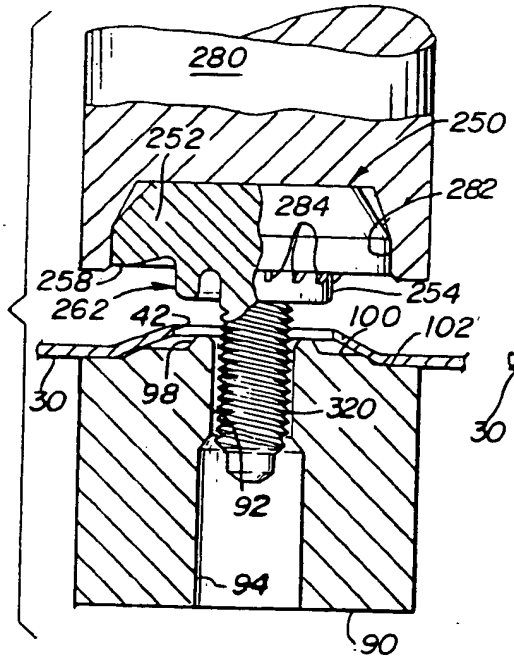
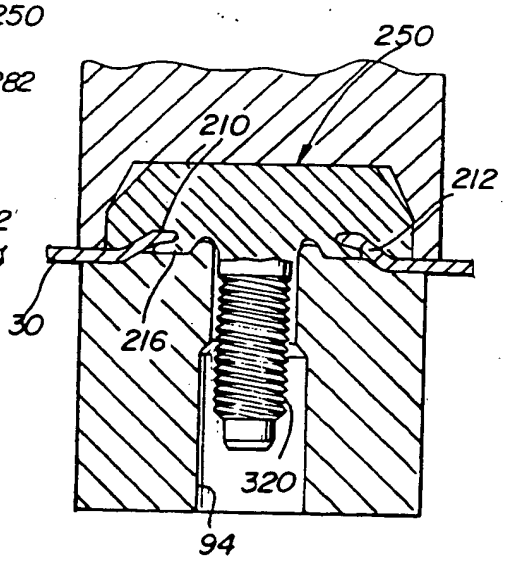


FIG-9



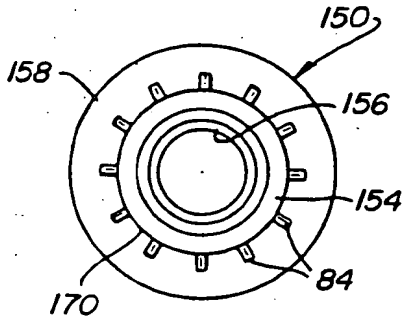


FIG-10

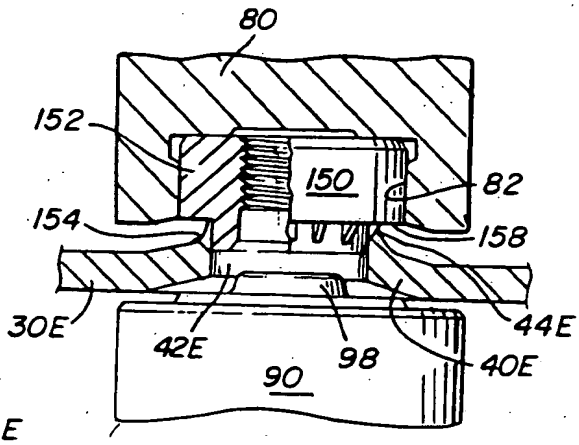


FIG-11

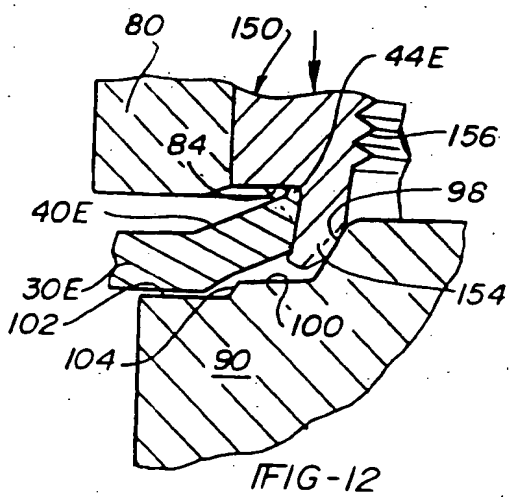


FIG-12

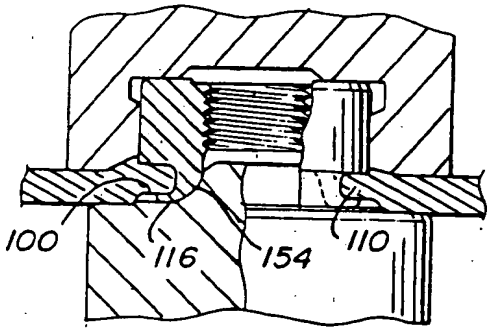


FIG-13

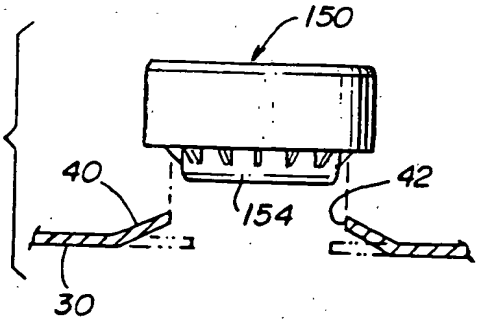


FIG-14

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 11 7466

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X A	US-A-1 502 399 (RENNER) * page 1, line 47 - line 77; figures *	20 1	B23P19/06 B21J15/02 F16B37/06
A	US-A-1 579 875 (LUNBERG) * page 1, line 68 - line 90; figures *	1,4,10	
A	JP-A-3 028 514 (IWATA BOORUTO KOGYO K.K.) 6 February 1991 * figures * & PATENT ABSTRACTS OF JAPAN vol. 015, no. 155 (M-1104)18 April 1991 * abstract *	1-5,7, 9-11,15, 17,21	
D,A	US-A-4 610 072 (MÜLLER) * claims; figures * * column 6, line 8 - line 21 * * column 12, line 49 - column 13, line 3 *	1-4,6,8, 9,18,20	
A	US-A-4 557 650 (MOLINA) * column 3, line 2 - column 4, line 9; figures *	12,14	TECHNICAL FIELDS SEARCHED (Int. Cl.5) B23P B21J F16B B21D
A	US-A-1 872 385 (ANDREN) * figures *	16	
A	US-A-3 878 598 (STEWARD) * column 5, line 9 - line 14; claim 1; figures 1-5 *	1,19	
A	GB-A-318 182 (HALL ET AL) * page 3, line 16 - line 42 * * page 2, line 96 - line 102; figures *	1,21,22	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	08 FEBRUARY 1993	PLASTIRAS D.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 11 7466

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	GB-A-2 068 493 (PROFIL-VERBINDUNGSTECHNIK) * claims; figures * -----	1,4,9, 20-22	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	08 FEBRUARY 1993	PLASTIRAS D.

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